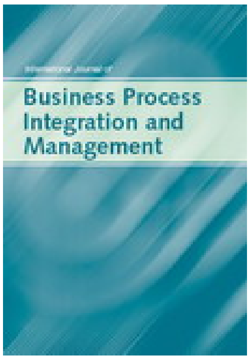

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Flexibility-based selection of paradigms and tools for BP modelling and execution

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Abstract: The last decades have witnessed several changes at the level of the development and the adoption of several business process management approaches, methodologies, tools and paradigms. These latter support all stages of the business process management life-cycle. Due to the continuous, increasing and rapid changes in the context or environment in which organisations operate, flexibility of business processes ranks high on the list of priorities of organisations. Hence, organisations must be able to respond promptly and effectively to these changes and unexpected turbulence. This research presents a generic approach for guiding business process engineers to choose paradigms and tools, for modelling and executing their business process, in the sense of taking into account their flexibility requirements. A case study is conducted considering the well-known Scrum framework as a business process for which the approach is applied. Business processes are analysed in terms of flexibility needs, and then our approach guides process engineers on the modelling paradigm and tools they can use accordingly.

Keywords: flexibility; business process management; BPM; paradigms; business process management systems; BPMS; guidance; scrum framework.

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1 Introduction

Business process management (BPM) has gained a significant and solid foothold, both in academia and industry (van der Aalst et al., 2016). The latest era has been meeting considerable developments and numerous scientific investigations of a set of BPM approaches, methodologies, tools, techniques and methods, in order to provide them with support for all stages of the BP life-cycle (Dumas et al., 2013).

In this context, traditional rigid BP modelling approaches have several problems when dealing with changes regarding their business processes. Over the last two decades, organisations have been suffering from unexpected turbulences, variety and uncertainty (Afflerbach et al., 2014). Accordingly, they have to react in a flexible manner in order to fit these sudden changes and unforeseen turbulences as well as addressing new challenges and rapidly changing circumstances. Therefore, organisations are forced to adapt their processes. Reinforcing this view, BPs must be able to respond to the flexibility needs of organisations and their information systems will need to be prepared for possible further changes right from the design phase (van der Aalst et al., 2018).

Regarding the continuously changing conditions, flexibility has become a must (Neuhuber et al., 2013) and as one of the major research topics in the entire spectrum of BPM. Thus, one of the challenges that emerged is the ability to provide business process models with flexibility requirements. Business process flexibility is defined in Schonenberg et al. (2008a) as the ability to deal with both foreseen and unforeseen changes in the context or the environment in which they do operate. The demand for flexibility in BPs is not only present in one field (Dadam and Reichert, 2009). It has gained a strong foothold in several fields such as: healthcare (Wang, 2012; Hicheur et al., 2012), software engineering (Holschke et al., 2010) and disaster management (Kittel et al., 2013).

Many alternative paradigms have emerged over the last decades in order to overcome the limitations which are caused by the traditional and the rigid business process modelling and execution approaches, such as the rule-based (Boukhebouze et al., 2011), the constraint-based (Pesic, 2008), the case handling (van der Aalst et al., 2005) and adaptive process modelling (Reichert and Dadam, 2009) approaches. The adaptive process management approach allows dynamic process changes at different levels (Rinderle-Ma and Reichert, 2010). The case handling paradigm focuses mainly on the case itself. The case is the central concept that consisted of the 'product' which is manufactured (van der Aalst et al., 2013; Wohed et al., 2009). The rule-based paradigm is based on business rules. In fact, the control flow, data flow and resource allocation is expressed by means of business rules. Business rules can define the semantics of BP models and business vocabulary (Sun et al., 2006).

From another angle of vision, many business process management systems (BPMSs) and tools were developed (Dumas et al., 2013). Similarly, flexibility support when executing a BP became one of their challenging features. Altogether, these concerns had created a demand for theory and practice to assist in the comparison and the evaluation of these paradigms and BPMSs regarding flexibility underlying concerns. However, using or even combining these paradigms to model and execute a certain business process with flexibility needs can be an advanced and knowledge intensive task. Process engineers have to be aware of how their flexibility needs can be addressed by the aforementioned paradigms, and as a result, which BPMSs better match these (often combined) paradigms to execute and manage their organisation's business processes models.

Within this streamline, our research work addresses the challenge of developing an approach to help process engineers choose business process modelling paradigms and tools that fit their organisation's BP flexibility needs efficiently. Therefore, in this particular stage, we outline that our main research question is 'how to help BP engineers to choose BP modelling paradigms and tools that best fit their needs in terms of BP flexibility?' Most precisely, this leads to narrowing the scope of the research questions into:

- How can the existing business process modelling paradigms and BPMSs be classified regarding flexibility?
- How should the ability of existing business process modelling paradigms be measured in order to deal with flexibility?
- How are BPMSs going to be scored regarding their flexibility support?

Due to the fact of software development being recognised as a process often subjected to change, flexibility (often coined as agility) has been lately considered an almost mandatory process requirement (Schwaber, 1995). More precisely, the Scrum framework[1] is designed to be flexible all along the project life cycle. It launches control mechanisms for planning a release, and then for managing the project's variables as it progresses. This allows organisations to modify the project and its deliverables at any time. As a matter of fact, delivering the most appropriate release becomes a mandatory target (Ionel, 2008).We conducted a case study to validate our approach, aiming at allowing a better comprehension of a Scrum-based software development process in terms of flexibility, according to Scrum experts and professionals.

This paper addresses the issue of guidance in the BPM context. For this purpose, the next section focuses on related work and involved considerations to discuss our guidance approach. The third section assesses the current state of the art with regard to basic concepts related to BP flexibility (definitions, BP flexibility taxonomies, flexibility in BPMSs, BP modelling paradigms). The fourth section reflects our suggested approach fostering flexibility. The fifth and sixth sections involve a couple of considerations to validate the proposed approach. In this setting, we make use of a case study based on the Scrum framework, and perform an analysis of the obtained results using our proposed general approach fostering BP flexibility. Finally, the last part discusses the contributions achieved as well as limitations that are still in place.

2 Related work and discussion on guidance in BPM context

Due to the recent advances and rapid growth of the BPM market, both software developers and users are in need of appropriate assessment methodologies (Cingil et al., 2012). BPM guidance addresses the issue of guiding process stakeholders (modellers, developers, participants, and analysts) during the different steps of the BPM life-cycle. The concept of guidance has hence been researched in the BPM community in the context of proposing principles and guidelines, providing recommendation systems or decision support systems.

Mendling et al. (2010) propose a set of seven process modelling guidelines, which directly aim to bring support to process modellers. Thomas et al. (2014) propose a set of ten principles that characterise BPM as a research domain and guide its successful use in organisational practice. Becker et al. (2000) presented a framework to structure factors for the evaluation of process models, while putting emphasis on six guidelines of correctness, relevance, economic efficiency, clarity, comparability and systematic design.

Barba et al. (2013) propose a recommendation system which assists users during the process execution to optimise the performance goals of the processes. Schonenberg et al. (2008c) provided in a service that assists users in selecting activities, during the process executions, by giving recommendations on possible next steps. In Setiawan et al. (2011), a recommendation system which is based on the capitalisation of previous practices and experiences within the organisation is presented.

Conforti et al. (2015) propose a recommendation system that supports process participants in taking risk-informed decisions, with the goal of reducing risks that may arise during process execution. Huang et al. (2012) propose an approach that guides physicians in clinical pathways by providing recommendations on the possible next steps based on the measurement of the target patient status and the medical knowledge from completed clinical cases. A system for supporting users at modelling time was presented in Koschmider et al. (2011). The system provides information that facilitates the decision for the (right) recommendation which is based on the user profile.

Table 1 Analysis of the mentioned BPM guidance projects

Guidance approaches	*What?*	*How?*	*General or specific domain?*
Mendling et al. (2010)	BP modelling	Principles/ guidelines	General
Thomas et al. (2014)	BPM	Principles/ guidelines	General
Becker et al. (2000)	BP models evaluation	Principles/ guidelines	General
Barba et al. (2013)	BP execution	Recommendation system	General
Schonenberg et al. (2008c)	BP execution	Recommendation system	General
Setiawan et al. (2011)	BP execution	Recommendation system	General
Conforti et al. (2015)	BP execution	Recommendation system	General
Huang et al. (2012)	BP execution	Recommendation system	Specific
Koschmider et al. (2011)	BP modelling	Recommendation system	General
Deng et al. (2016)	BP modelling	Recommendation system	General
Cingil et al. (2012)	BPMSs evaluation	Decision support system	General
Yao and Kumar (2013)	BP execution	Decision support system	Specific
Our guidance approach for business process flexibility	Paradigms and BPMSs evaluation regarding flexibility	Decision support system	General

A process recommendation system is proposed in Deng et al. (2016) to help BP analysts build new processes from scratch in an efficient and accurate way. In order to provide guidance to users during the process execution, a recommendation system was proposed in Mertens et al. (2014).

Other research efforts were engaged in developing decision support systems. In fact, a decision support system was developed in Cingil et al. (2012), including a relational database to keep the predefined relations, its descriptions, its inputs for weights, its grades and calculated scores. On the same track, a clinical decision support system, which provides decision support in order to get adaptable clinical pathways, has been proposed in Yao and Kumar (2013).

An overall analysis of the aforementioned BPM guidance projects is illustrated in Table 1. We analysed them considering three main questions:

- What is the main purpose of the guidance approach?
- How do authors achieve it?
- Was it developed for a specific or a general domain?

Although guidance approaches has already been widely used in academic research, it is a relatively new topic in the BPM domain. Table 1 presents some research works that utilise the concept of guidance to support users in the modelling or execution of their processes. Most of these works suffer from a principal problem. Indeed, they do not consider the whole BP life-cycle for guidance (exception is made for the research presented in Thomas et al. (2014). On the other hand, only one of the analysed works [the proposed work in Cingil et al. (2012)] sought to provide detailed guidelines to choose the most suitable BPMSs according to the selected criteria.

In most of these approaches, the focus on flexibility and user assistance can be observed. However, they do not support, in a straightforward way, BP flexibility requirements or guidance. Moreover, the need for increased attention to flexibility, the competing paradigms and the wide variety of BPMSs have been recognised by both academia and industry. Nevertheless, to the best of our knowledge, none of the research works directly targets the development of a guidance system that takes into account the flexibility and the multitude of paradigms and BPMSs. Upon the recognition of such scarcity, we propose in this paper a guidance approach in order to guide users to choose the most convenient paradigms and BPMSs, according to their particular needs in terms of business process flexibility.

3 General context

BP flexibility is framed as an important quality measure for the increased performance of companies in volatile markets (Holschke et al., 2010). Research works which are related to BP flexibility in the literature have grown widely and significantly, including definitions, taxonomies, developing tools and paradigms. Most of the early works began to put under scrutiny BP flexibility, focusing on defining and compiling robust definitions of BP flexibility while introducing new concepts.

3.1 BP flexibility

Authors claimed, in Daoudi and Nurcan (2005), that BP flexibility is "the fast reactivity to internal and external changes that affect the enterprise and the easiness to modify BPs schemes and to setup the new enterprise activity." They also asserted that flexibility is "reflected by the ability that the information system has to take into account enterprise activity changes."

Regev and Wegmann (2005) defined that BP flexibility is as "the amount of change that a process can accept in the presence of such perturbations." They added that it is "the ability to yield to change without disappearing, i.e., without losing identity."

Pesic and van der Aalst (2006) proposed to view BP flexibility as "the ability to change or deviate from the business process." They also stated that it "plays an important role in the extend to which such systems can support dynamic processes."

Regev et al. (2006) claimed that BP flexibility is the possibility "to change (BPs) without replacing (them) completely." Besides, they propose to define this concept as the "capability to implement changes in the business process type and instances by changing only those parts that need to be changed and keeping other parts stable."

Table 2 Characterisation of the BP flexibility definitions

Reference(s)	*Criterion 1*	*Criterion 2*	*Criterion 3*	*Criterion 4*
Daoudi and Nurcan (2005)	The fast reactivity to changes	Yes (internal or external)	No	No
Regev and Wegmann (2005)	The amount of change	No	No	No
Pesic and van der Aalst (2006)	The ability to change	No	No	No
Regev et al. (2006)	The capability to implement changes	No	No	Yes
Schonenberg et al. (2008a, 2008b)	The quality of a process	Yes (foreseen and unforeseen)	No	No
van der Aalst (2013)	The ability to deal with changes	No	Yes	No

BP flexibility is defined, in Schonenberg et al. (2008a, 2008b), as the "quality of a process (which) reflects its ability to deal with (foreseen and unforeseen) changes, in the context or in the environment in which they operate." They mentioned that it consists of adapting the parts of the business process that are not impacted by the variations, while retaining the essential format of the other parts.

van der Aalst et al. (2013) claimed that flexibility "can be viewed as the ability to make choices at different points in time (design time, configuration time, or runtime)".

When analysing the definitions above, we have observed that there are many similar points. Accordingly, we have put under scope four relevant criteria that can characterise authors' definitions:

- Criterion 1: What is BP flexibility?
- Criterion 2: Have the drivers of change been evoked?
- Criterion 3: Have definitions emphasised on the BPM life cycle (design or run or configuration time)?
- Criterion 4: Have the instance or model abstraction levels been mentioned?

To start, Table 2 represents a characterisation of these definitions. In this work, we propose a definition of BP flexibility that incorporates all the criteria that we have already identified. BPs flexibility could be defined as:

> "The ability to deal with changes of different types (foreseen and unforeseen, internal and external), at different points of time (design time, configuration time and run time), in the BP instance and model/type."

3.2 BP flexibility taxonomies

Several flexibility taxonomies have been proposed, including the ones by Reichert and Weber (2012), Schonenberg et al. (2008a), Regev et al. (2006) and Nurcan (2008). In this paper, we will mainly study thoroughly the flexibility taxonomy proposed by Regev et al. (2006). We adopt this taxonomy since it displays means for classification to flexibility with respect to the types of changes it foresees. We find it also generic enough to allow us to define the flexibility criteria (FC) which we will use to analyse and also to compare the selected BPMSs.

It includes three orthogonal (combinable) dimensions: the abstraction level of change, the subjects of change and the properties of change.

The abstraction level of change goes back to the fact that changes can occur in the process type/model or the instance/case levels, or both of them. Changing the process model/type implies changing the standard way of working thereafter, since all future instances of the process will now be based on the altered model. The altered type has to be executed and process instances have to be created. It often reflects the redesigning of the processes. Whereas, changing process instances means, that a deviation from the standard way of working is created for specifically one or few more instances.

The subject of change considers diverse elements of a process that can be changed (essentially, these elements include sub-processes, activities, data inputs and outputs, decision, fork and join control-flow elements, resources and tools/systems that support the execution of a process). It can be differentiated by associating them with different perspectives. Those perspectives can be found in the type and the instance layer. In Regev et al. (2006), they considered five basic perspectives. Speaking about the functional perspective, it describes what the process has to do; particularly it defines the process goal. As fore the operational perspective, it describes executed activities during the process. The behavioural perspective, it defines, when and under which preconditions activities are performed. In the informational perspective, the information which shall be exchanged between activities is defined. The organisational perspective describes who participates and which roles will be playing in the process. We can not carry on without mentioning that the additional perspectives may also be considered for BPs, if needed in special environments.

The properties of change include extent, duration, swiftness and anticipation of change. The extent of change refers to the accomplished amount of change, either being applied to an existing process model (incremental change), or abolishing it and ending up with creating a completely new one. The duration of change refers to if a certain change will last temporarily (only for a period of time), or permanently (until the next change). Swiftness of change reflects the choice between an immediate propagation of change over the existing process instances (including the running ones), or a deferred propagation affecting only new instances of the changed process. The anticipation of change refers to planned or previously modelled and expected changes, or ad hoc or unforeseen ones.

4 Proposed general approach

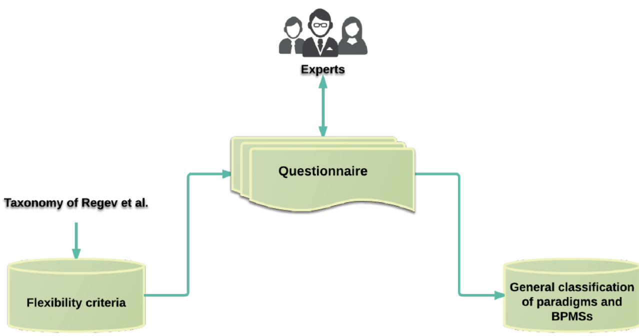
In this section we describe our approach, which consists of two steps:

1. A general classification of BPMSs and process modelling paradigms.
2. The proposal of a guidance procedure that foresees inputs from users regarding their needs in terms of BP flexibility, and then guiding them to choose the best-suited BPMS for their organisations.

4.1 Main research activities

Figures 1 and 2 present the main activities developed within these major two steps.

Figure 1 Overview of step 1 of our proposed approach (see online version for colours)



These activities can be summarised as below:

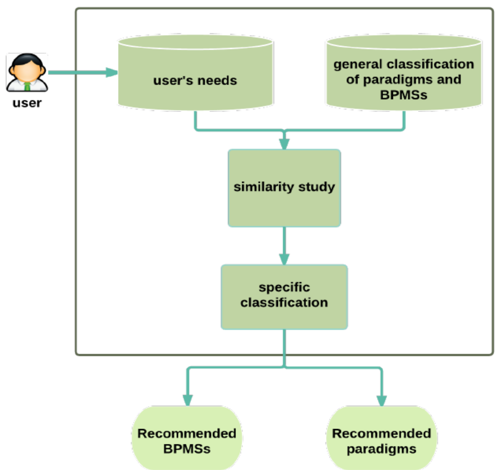
a. Classification of BPMSs

- FC: We began by identifying a set of criteria which we derived from Regev et al.'s taxonomy, in order to evaluate flexibility within BPMSs. From this activity we have specified 11 FC (as detailed in the next section).
- Questionnaire – 'Evaluation of business process management systems (BPMS)': Hereby, we developed a questionnaire for BPMS developers and researchers to answer, based on their advanced knowledge of the BPMSs either at the level of research or development. We also selected these BPMSs taking into account their prominence in literature, as well as their ability to support BP flexibility. We could then analyse the replies on the questionnaires and classify the BPMSs accordingly, regarding their support on flexibility and modelling paradigms.

b Guidance procedure

- BP flexibility needs: As for now, we have to identify the flexibility needs from the users of our BPFlexGuide software system. This step implied efforts of mapping the well-known flexibility taxonomy of Regev et al. into a set of questions to be understood by BP engineers without a profound knowledge of BP flexibility.
- Similarity study: We compare the obtained answers from the users' needs questionnaire from the first side with the previous classification of BPMSs from the other side, in order to derive a score in terms of flexibility.
- Specific classification: Actually, we tend to classify and sort the BPMSs and modelling paradigms with an algorithm (which was detailed in the next section, and present the associated recommendations to users.

Figure 2 Overview of step 2 of our proposed approach (see online version for colours)



In the next section, we display the results and calculations which we derived from each one of these research activities.

4.2 Basic elements of our approach

In this section, we describe the main elements on which our research is based. These include the identification of FC for evaluating BPMSs, the design of the questionnaire and obtained answers, and the calculations and developed algorithms in order to assess the BPMSs against needs regarding the BPs flexibility.

Based on Regev et al.'s aforementioned taxonomy, we began by identifying a set of BP FC. We have specified 11 FCs, which are related to the following questions:

- FC1: To which extent do the BPMS modellers describe the process control flow?
- FC2: To which extent does the BPMS support descriptive modelling and execution of process activities?
- FC3: To which extent does the BPMS support descriptive modelling and execution of the preconditions of the activities?
- FC4: To which extent does the BPMS support descriptive modelling and the execution of exchanged data/information between the process activities?
- FC5: To which extent does the BPMS support the descriptive modelling and the execution of roles associated to the process activities?
- FC6: Does the BPMS support the changes to process models which will affect all new process instances?
- FC7: Does the BPMS support changes at the instance level, and that will only affect certain selected instances, in order to accommodate exceptional situations?
- FC8: Can the BPMS support the incremental change and/or the revolutionary change?
- FC9: How would the duration of change that the BPMS support be characterised as temporary and/or the permanent?
- FC10: Is the BPMS able to deal with immediate and/or deferred change?
- FC11: Can the BPMS support planned or ad hoc changes?

It is important to mention that all FCs have the same weight. We have specified for each FC a scale in order to get consistent results. FC1, FC2, FC3, FC4 and FC5 range from 0 (not descriptive) to 5 (very descriptive). As for FC6 and FC7, they can be 1 (yes) or 0 (no). It is worthy to differ between the other results since FC8, FC9, FC10 and FC11 can take 1 (if it satisfies one of the characteristics describing these criteria), 0 (if it does not satisfy none of the characteristics) or 2 (in regard if it does not satisfy both characteristics).

Table 3 Responses of the questionnaire for each BPMS

	DECLARE	*ESProNa*	*JRules*	*AristaFlowBPM suite*	*PHiharmonicFlows*	*ProdProc*	*jBPM*	*FLOWer*
FC1	2	3	4	4	2	2	5	1
FC2	5	3	4	5	3	4	5	2
FC3	2	4	3	3	5	4	3	2
FC4	2	3	1	5	5	3	5	2
FC5	2	3	2	5	4	3	3	2
FC6	0	0	1	1	1	1	1	1
FC7	1	1	1	1	1	0	1	1
FC8	1	1	1	2	1	0	2	2
FC9	1	1	1	2	1	1	1	1
FC10	1	1	1	2	1	1	1	1
FC11	1	2	1	2	1	0	2	1

4.3 Questionnaire for BPMS providers

The questionnaire has been designed in order to evaluate flexibility in BPMSs from the angle of vision of a provider. The questionnaire was specifically designed to seek responses from the most senior personnel responsible for the development of the selected BPMSs. It has been filled out by senior developers/researchers who provided us with answers for the corresponding BPMSs: DECLARE, ESProNa, Jrules, AristaFlow BPM suite, PhilhamonicFlows, jBPM, ProdProc and FLOWer.

Most of the BPMSs from which we derived answers were developed in the context of research projects. Others were developed by professional developers from the industry. We can not skip to highlight the fact that our approach is extensible in the sense that any supplementary answer from experts can be included in our study and will be taken into consideration in the following steps. Table 3 represents the responses for each BPMS. According to the questionnaire's outcomes, Table 4 summarises the answers to the following question: "what is (are) your BPMS's underlying modelling/execution paradigm(s)?" Based on Table 4, we can interpret that most of the selected BPMSs support constraint-based modelling (5 out of 8). Besides, 5 out of 8 are oriented as mono-paradigm systems. We can also observe that 2 out of 3 multi-paradigm systems combine the constraint and rule-based paradigms.

4.3.1 Match between users' BP flexibility needs and BPMSs' announced flexibility

In this section, we aim at comparing the elements of the users' needs in terms of flexibility in BPs and the elements of the responses of the questionnaire presented in Table 3. Our study is build upon a similarity metric in order to measure distance, more specifically the overlap metric. According to (Kumar, 2012), the overlap metric simply tests for equality between two values, so that different values get distance 1. Hence, equal values get distance 0.

Table 4 BPMS classification according to their modelling paradigms

BPMS/ paradigm	*Constraint-based*	*Rule-based*	*Case handling*	*Adaptive process support*	*Total*
DECLARE	Yes	Yes			2
EsProNa	Yes				1
Jrules	Yes	Yes			2
AritaFlow BPM suite				Yes	1
Philharmonic flows			Yes		1
ProdProc	Yes				1
jBPM		Yes			1
Flower	Yes		Yes		2
Total	5	3	2	1	

Definition 4.1: Definition of the overlap distance

$$d_{overlap}(x, y) = 1 \text{ when } x \neq y$$

$$d_{overlap}(x, y) = 0 \text{ when } x = y$$

4.3.2 Algorithm for specific classification of BPMSs

The objective of the upcoming point is to find out an algorithm in order to calculate this similarity score for each BPMS. To do so, we follow a methodology that includes the following steps:

1. Compare the users' FC with the different BPMS FC.
2. Assign a calculated similarity score for each criterion. The score is either 0 or 1, where 0 indicates no similarity and 1 indicates identical elements.
3. Sum all the criteria to obtain a similarity score SIM for the considered BPMS.
4. Compare the calculated scores for each BPMS in order to sort them.

Definition 4.2: We consider two sets S and U. S is the set of the different BPMSs. Each S_i refers to its FC. U is the set of the criteria entered by the user. Let n be the number of studied systems and NCR be the number of studied FC.

Furthermore let

$$S = (S_1, S_2, S_3, \ldots, S_n)$$

$$U = (FCU_1, FCU_2, FCU_3, \ldots, FCU_{NCR})$$

$$S_i = (FC_{1i}, FC_{2i}, FC_{3i}, \ldots, FC_{NCRi}).$$

We define the similarity score for each system as represented below:

$$SIM_i = \sum\nolimits_{j=1}^{NCR} sim_{ij}$$

where $sim_{ij} = d_{overlap}(FCU_j, FCj_i)$

Next, we do the sorting of the S_i according to the calculated similarities. $SORT_S = sort_i^n\{SIM_i\}$ where $i \in [1, n]$.

4.3.3 *Algorithm for classification of paradigms*

We consider the following steps in order to calculate the flexibility measurement score for each paradigm as highlighted below:

- Calculate, for each BPMS, the similarity score (SIM) (as executed in the algorithm for the classification of BPMSs).
- Sum the similarity scores in case the BPMS belongs to the paradigm.
- Compare the flexibility measurement scores of the different paradigms.

Definition 4.3: Here we consider an additional set P of considered paradigms. Let n be the number of studied systems, m the number of studied paradigms, NCR be the number of studied FC.

Furthermore let

$$S = (S_1, S_2, S_3, \ldots, S_n)$$

$$U = (FCU_1, FCU_2, FCU_3, \ldots, FCU_{NCR})$$

$$S_i = (FC_{1i}, FC_{2i}, FC_{3i}, \ldots, FC_{NCRi})$$

$$P = (P_1, P_2, P_3, \ldots, P_m).$$

Each S_i belongs to one or more paradigms. We define the flexibility measurement score of the paradigms (PFMS) for each paradigm as follows

$$PFMS_j = \sum_{k=1}^{n} SS_k$$

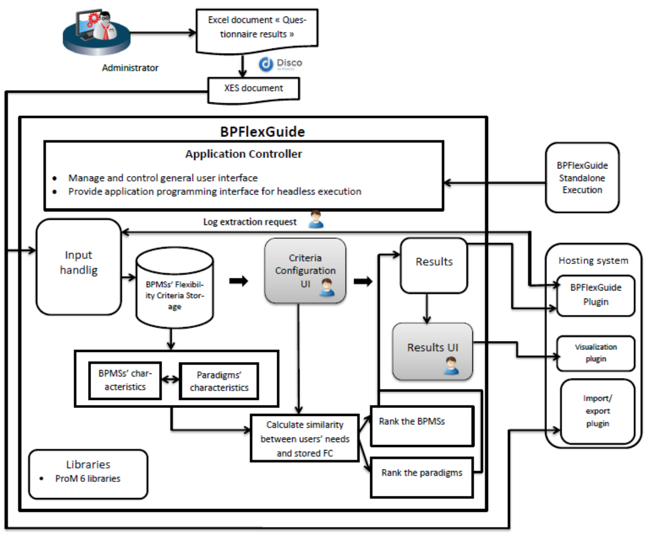
where $\begin{matrix} SS_k = SIM_k & \text{if } S_k \in P_j \\ 0 & \text{otherwise} \end{matrix}.$

Next, we do the sorting of the S_i according to the calculated similarities $SORT_P = sort_j^m\{PFMS_j\}$ where $j \in [1, m]$.

4.4 *Implementation of the BPFlexGuide tool*

In this research work, the conducted approach is supported and tested by a corresponding tool implementation. It is worthy to mention that we did not develop a tool from scratch, but rather as a ProM plug-in tool. ProM has a global application controller which is responsible for managing the general user interface (UI), the flow between the initial input setup, metric configuration and result handling, and also provides an application programming interface (API) to perform all steps.

Figure 3 The BPFlexGuide architecture (see online version for colours)



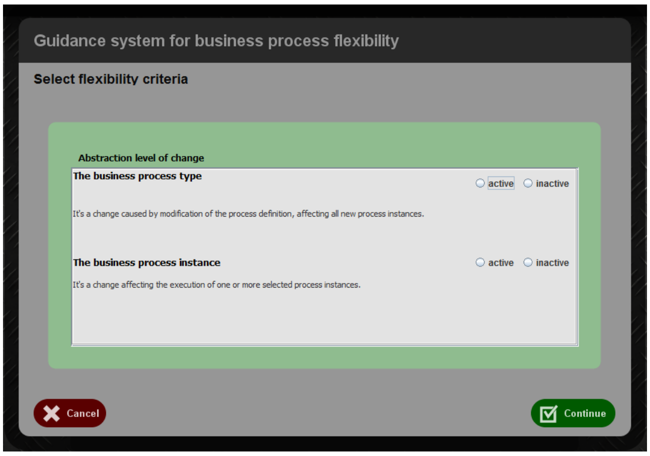
BPFlexGuide is a plug-in that allows optionally specifying a previously saved project to resume or restart an experiment. The starting point is a spreadsheet-based (MSExcel) document that contains the results of the questionnaire (which were presented in Tables 3 and 4). It has been transformed to a data structure that conforms to the eXtensible Event Stream (XES) format. As shown in Figure 3, this XES document serves as an input to our BPFlexGuide. When starting our BPFlexGuide tool, an internal repository of all the BPMSs' FC is constructed. This is done when extracting the BPMSs' FC for each BPMS from the XES document. The BPMSs' FC have been implemented as classes. Then, the configuration of all the BPMSs and the paradigms is conducted. Next, the user can pick, out of a list, the flexibility criterion which best fits her/his needs on the flexibility. The provided UI allows configuring the users needs on flexibility [based on the taxonomy of Regev et al. (2006)]. Her/his choices are then stored. In order to provide an easy means to configure each criterion, three UI components can be used, which allow modifying a criterion configuration. The UI components deal with the abstraction level of change, the subject of change and the properties of change dimensions. The architectural aspect allows the separation between the UI (view) components and the program logic (e.g., the calculation of similarity between the needs of the users as well as the criteria of BPMSs and paradigms).

The most important step consists in calculating the similarity between the flexibility users needs and the stored FC. To accomplish this point, we have implemented the algorithms presented in the previous section. The result of the execution of these algorithms is the rank of the different BPMSs and of the modelling paradigms. Finally, these results are shown to the user. In case the same ranking is obtained for two BPMSs, the user picks one of the BPMSs. Figure 4 shows a caption of our BPFlexGuide tool.

5 Applying our guidance approach to Scrum

García-Magariño et al. (2009) outlined that modelling software development processes is necessary and very useful. There are many reasons for that. Indeed, this important issue leads to a better process understanding. It also facilitates process measurement and improvement. Besides, it constitutes the basis for automating the process itself. Another reason is that it facilitates the software development process understanding to inexperienced designers, based on the software development process models defined by experienced ones. Many research work focused on modelling Scrum-based development process such as Damiani et al. (2007), Pino et al. (2010) and Kennett (2013).

Figure 4 The BPFlexGuide tool (see online version for colours)



During the last few years, agile software development approaches have become more popular. Several methods have been developed with the aim to deliver software faster and to ensure that the software meets the customer changing needs (Paetsch et al., 2003). On the other hand, the change is fundamental to product innovation, which is about bringing something that has not existed before (Smith and Radeka, 2009).

Agile practices emphasise flexibility by avoiding upfront design, bulky requirements engineering, voluminous documentation and rigorous rules. They focus on an involvement of the costumer, flexible adaption to changes and an iterative proceeding with extensive communication, author-critics cycles and permanent feedback on all levels (Sauer, 2006). Flexibility is a central skill for software development. It is required to react to and minimise the effects of inevitable problems (Estler et al., 2012).

Because software development is complicated and complex, a maximum flexibility and an appropriate control is required. Moreover, the evolution favours the development software processes that operate with maximum exposure to the environmental change and have been optimised for flexible adaptation to change (Schwaber, 1995). This can lead to variability in the designed business processes and their supporting applications and infrastructure technology (Rurua et al., 2017). Added to that, flexibility in software development is defined in the book by Smith (2007) as the changes that occur during the process of developing a software product. It is the ability to make changes in the product being developed or in how it is developed, even relatively late, throughout the development cycle, without being too disruptive. The less disruptive these changes are, the more flexible the process is Smith (2007).

5.1 Eliciting flexibility needs of Scrum-based software development processes

The Scrum framework is known by its ability to accommodate changes that often occur in software development projects. Its main feature is flexibility and at the same time it offers mechanisms for controlling and improving the performance of the project. Thus, Scrum is designed to be flexible all along the project life cycle. It provides control mechanisms for planning a release, and then for managing the variables of the project as it progresses. This allows organisations to modify the project and its deliverable at any time. As a consequence, these latters will deliver therefore the most appropriate release (Ionel, 2008).

5.1.1 Research method – survey

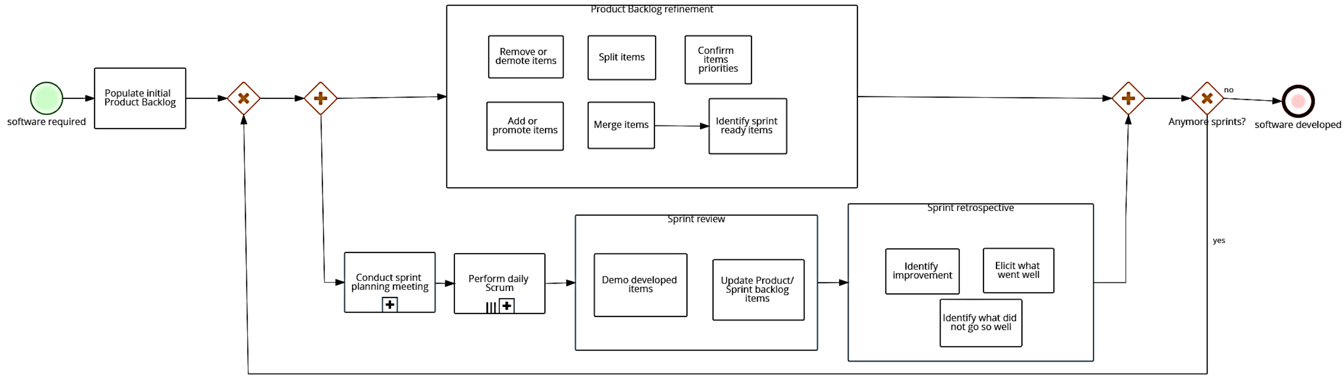
5.1.1.1 Overview

In this study, the main research method was a survey. The first version of the survey was sent to a professional Scrum master for reviewing. Based on his feedback, the survey was revised accordingly before it was distributed among potential respondents. The target group of this survey was the professionals who are experienced enough on Scrum.

5.1.1.2 Survey content and distribution

The survey was digitally implemented using an online survey tool. It was distributed among Scrum professionals all over the world through the LinkedIn professional network.[2]

Figure 5 Scrum process modelled in jBPM (see online version for colours)



The questionnaire was grouped into the following three sections:

1 personal information

2 flexibility of your Scrum

3 guidelines for a flexibility-enabled Scrum software tool.

The aim of the first section was to gather enough background information of the respondents and their roles in their companies. The second section was planned to collect the data about the flexible (can be changed) and the rigid (fixed) parts of their tailored Scrum, since it is commonly enforced in their companies. As for the third section, it was designed to get information from the respondents about their needs in terms of flexibility, in order to guide decision-makers to choose the best suited software tools. This section was developed using the taxonomy for the business process flexibility which was presented by Regev et al.

We collected 46 answers to our survey. The target population of this survey of this survey is the following:

- Scrum users: It is a group of people who use Scrum on a daily basis for their normal working practice.
- Scrum Alliance, Inc.: It is the largest, most established and influential professional membership organisation in the Scrum community.
- Scrum.org: The group mission is to spread knowledge and support the implementation of the Scrum framework and other agile practices.
- Certified Scrum Master Global: This group is dedicated to all certified Scrum masters.

5.1.1.3 Tailoring Scrum

Our approach consists in guiding decision makers to choose the best software tools that satisfy their needs in terms of flexibility for Scrum. We are inspired in this research from published works such as the work of Bass (2014) and Hossain et al. (2011), which are related to tailoring Scrum. It is important to mention that each survey question was accompanied by a practical example in order to enhance its understandability to the Scrum professionals.

More broadly, the software process tailoring is concerned with taking generalised software development approaches and tailoring them by using adjustments to accommodate specific software development settings.

5.1.2 Survey results

There were 46 respondents who finished the question company name in the survey. Some of the companies that were mentioned as responses to the questionnaire are now ranked in Fortune 500[3] (one of the companies is ranked 23, another is ranked 53, another is ranked 567, and another is ranked 791). Concerning their countries, most of them are from the USA, India and Brazil.

Regarding the fundamental activities of Scrum, around 30 out of 46 respondents answered that the product backlog is flexible. Half of the respondents mentioned that the sprint review and the sprint retrospective can be changed. Around 28 out of 46 had replied that the daily Scrum is rigid. According to 25 out of 46 respondents, the sprint planning cannot be subject to changes.

Concerning Scrum artefacts, the vast majority of the respondents held that the product backlog and the sprint backlog are the most used artefacts during Scrum. However, we have obtained only 16 responses considering that the product increment is the most used artefact.

Table 5 Flexibility needs of the responding Scrum professionals

FC	*Value or weight*	*Number of responses*	*Considered response*
FC1	Yes	30	Yes
	No	16	
FC2	Yes	27	Yes
	No	19	
FC3	0	2	4
	1	0	
	2	10	
	3	16	
	4	18	

Table 5 Flexibility needs of the responding Scrum professionals (continued)

FC	*Value or weight*	*Number of responses*	*Considered response*
FC4	0	4	4
	1	1	
	2	13	
	3	13	
	4	15	
FC5	0	7	3
	1	7	
	2	11	
	3	12	
	4	9	
FC6	0	5	4
	1	3	
	2	9	
	3	13	
	4	16	
FC7	0	8	4
	1	4	
	2	4	
	3	13	
	4	17	
FC8	Incremental	29	Incremental
	Revolutionary	4	
	Both	9	
	None	4	
FC9	Temporary	17	Temporary
	Permanent	13	
	Both	10	
	None	6	
FC10	Immediate	20	Immediate
	Deferred	13	
	Both	6	
	None	7	
FC11	Planned	12	Ad hoc
	Ad hoc	20	
	Both	7	
	None	7	

We deduced that all the main Scrum roles enforce changes. Almost the entire respondents think that the development team is the most responsible for changing Scrum, followed by the product owner and the Scrum master.

5.1.2.1 The abstraction level of change

Regarding the abstraction level of change, we consider in our study the Scrum-based process type and the Scrum-based process instance. 30 respondents among 46 think that it would be useful to have a software tool to manage several Scrum type (model) variants (templates) that could be instantiated and executed to track the progress of each Scrum project. For example, it is possible to "kick on a new small project, so we'll pick Scrum for small projects template and start from there." Twenty seven respondents think that it would be useful to have a software tool to register changes in certain running instances of a pre-selected Scrum model, in order to accommodate exceptional project situations.

5.1.2.2 Dimensions

Our study focused on the five known dimensions of software development processes, defined in the research study by Regev et al. (2006), which are the functional, operational, behavioural, informational and organisational dimensions. This part concerns the question related to flexibility "what are the dimensions of change involved?" Concerning the functional dimension, only two respondents think that it would not be useful to describe Scrum-based processes and structures, such as the names, the goals and the activities of the process.

While answering the upcoming question "would it be useful to model the activities executed during the Scrum process?", most of the respondents have answered positively. When asking Scrum professionals about the behavioural perspective, 39 respondents believe that it would be useful to have a software tool to define when and under which preconditions some Scrum activities are performed. Almost 41 respondents were in favour of having a software tool to register all data and artefacts (such as architectures, release plans, sprint plans, spikes, backlogs, tasks, features, burn-down charts, etc.) which were exchanged between the Scrum activities. Concerning the organisational perspective, only eight respondents believe that it would not be useful to have a software tool to register users and assign whose roles to them as well as tasks within a certain Scrum project.

In order to examine the properties of change, our study includes the extent of change, the duration of change, the swiftness of change and the anticipation of change, recalling Regev et al.'s taxonomy on BP flexibility. For the extent of change, 29 out of 46 respondents answered that it would it be useful to allow for changes in a Scrum model template (for instance, to add one daily scrum to the template). Most of the respondents answered that it would be important to allow registering temporary changes (i.e., limit a change for a certain period of time, and reset it afterwards). An example of temporary change is "if some task of the sprint is left undone, it can go back again into the product backlog." This may happen because a team is inexperienced in the business domain or is using a new technology. 20 out of 46 respondents answered that changes to the Scrum-based model should be immediately propagated to running projects (for instance, "make spikes mandatory for now on, including running projects." 20 out of 46 respondents think that any change can be made to the Scrum model templates or running instances. Only 12 respondents think that the Scrum model must include all possible paths of change and corresponding conditions (i.e., planned changes). For example, the Scrum user "can skip daily scrums if and only if team members and scrum master share the same working space."

5.1.2.3 *Synthesis of the flexibility needs of the responding Scrum professionals*

Table 5 sums up the obtained results from the responses of the part of the questionnaire 'Guidelines for a flexibility-enabled Scrum software tool'.

5.2 *Applying our approach to the Scrum development process*

Using our BPFlexGuide tool, we have considered as input the results of the questionnaire on flexibility needs, answered by Scrum professionals. This section shows the result of the BPFlexGuide tool which was applied to Scrum. The goal of the case study was to investigate whether Scrum can be considered as a flexible process and to help Scrum users to choose the most appropriate BPMS and paradigm that best suit their needs on flexibility. The tool gives as output a ranking of the most suitable BPMSs and modelling paradigms. As a result, Scrum professionals were guided to use the jBPM system as well as the rule-based paradigm. Thus, we have proposed to model Scrum using the jBPM system. Using the results presented in the previous section, we noticed that the product backlog, the sprint review and the sprint retrospective activities are almost flexible. However, according to our study the sprint planning and daily scrum cannot be subjected to changes. Figure 5 presents Scrum modelled with the jBPM tool, using BPMN as a modelling language. Regarding flexibility, the Scrum-based process allows Scrum professionals to decide what should happen through the use of ad hoc sub-process modelling elements. These elements provided the flexibility to add additional steps and deviate from the proposed plan. While a large part of the process is still well structured (as shown by rigidly linked tasks in the Scrum process model of Figure 5), the Scrum professional can decide which tasks should be performed as part of the aforementioned different ad hoc sub-processes (product backlog refinement, sprint review and sprint retrospective sub-processes). As mentioned in the guide of Scrum Alliance (2013), the product backlog refinement is not limited to:

- keeping the product backlog prioritised
- removing or devaluing items that no longer seem important
- splitting items into smaller items
- merging items into larger items
- estimating items.

Depending on the nature of the software product, the Scrum professional is responsible for selecting which of the different process fragments to execute. S/he is also able to add other inputs and skills which may be needed.

The sprint review sub-process contains two main user tasks which are the demonstration of the product increment and the update of the product backlog. The Scrum professional is responsible for selecting what to do next and can dynamically add new tasks.

In the ad hoc sub-process 'sprint retrospective', the Scrum professional is responsible for selecting which user tasks to execute. In addition, he is also able to add new tasks or repeat tasks for a couple of times. The professionals may identify what went well and unwell, and identify potential improvements. The Scrum team improves its own process, always remaining within the Scrum framework (Scrum Alliance, 2013). The Scrum cycle repeats for each sprint.

6 Conclusions and further work

In this paper, we developed a framework for guiding users to select the most appropriate BPMSs and paradigms that fit best their needs on flexibility. For this purpose, a two-step methodology was described. First, we developed a questionnaire in order to capture the perceived BPMSs strengths and weaknesses in terms of flexibility, from their own researchers and developers. This first step was based on the taxonomy of Regev et al. (2006), regarding the classification of business process flexibility.

Second, we have proposed a guidance approach using the questionnaire results. Our approach is meant to guide users to choose paradigms and BPMSs that best fit users needs in terms of business process flexibility. It has been encoded in algorithms and it has been implemented as the BPFlexGuide plug-in. Our BPFlexGuide plug-in takes as input the users' needs in terms of flexibility and provides as an output the ranking of BPMSs and the corresponding modelling paradigms according to the user's needs in terms of flexibility, namely regarding the dimensions (abstraction level of change, subjects of change and properties of change) that were identified in the taxonomy of Regev et al. (2006).

Our approach was validated using a case study. The case study aims to contribute with an understanding of the controlled flexibility in Scrum. In fact, it identifies its rigid and flexible parts under a scientific approach. Besides, it guides Scrum professionals to choose the most appropriate BPMS which fits best their needs in terms of flexibility when using Scrum. In addition, this study was conducted using a questionnaire that was sent to Scrum professionals. When scrutinising the results of the questionnaire and using our developed plug-in 'BPFlexGuide', we have deduced that the jBPM system is the BPMS which meets most of the Scrum professional needs. Therefore, we have modelled the Scrum process using the jBPM system, on which we have modelled the flexible parts using ad hoc sub-processes.

Our approach combines support to users and evaluation of existing BPMSs and paradigms. Despite the fact that the methodology could be tested with a naturally flexible process (Scrum-based software development process), but there are still many opportunities for future and promising improvements.

Our guidance approach still requires future work, in order to realise better results, namely the first step of our approach, which opened several interesting challenges. Our BPFlexGuide plug-in takes as input a document that includes the questionnaire results. When implementing this document by new results regarding BPMSs or paradigms, the plug-in will be updated. The BPMSs were selected because of their frequent usage and reference in the BPM research area. Other BPMSs can also be considered by our approach such as IBM business process manager.[4] Besides, we can focus on new criteria related to other BP modelling requirements that were not considered in our work. On the other hand, this study was based on the result of a critical and comprehensive analysis of four prominent process modelling paradigms enabling flexibility. Therefore, our approach can include other paradigms that may respond to various BP flexibility requirements such as the artefact based paradigm, the data-centric paradigm and the aspect oriented paradigm.

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Notes

1 Scrum is an agile project management framework that helps teams structure and manage their work through a set of values, principles, and practices.

2 LinkedIn is a social networking site which was specifically designed for the business community.

3 Fortune 500 is an annual list of the five hundred largest US industrial corporations, as measured by gross income.

4 It is a comprehensive business process management platform. It provides a robust set of tools to author, test, and deploy business processes, as well as full visibility and insight to managing those business processes.